

*DIRK C HOFMAN*

**GOVERNOR'S PASSAIC VALLEY FLOOD CONTROL COMMITTEE**

**PASSAIC VALLEY FLOOD CONTROL**



520 EAST STATE STREET  
TRENTON, NEW JERSEY

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## **GOVERNOR'S PASSAIC VALLEY FLOOD CONTROL COMMITTEE**

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The following report has been prepared to serve as a general guide in the development of an equitable plan of flood control for the Passaic Valley which is acceptable to all interests of the basin.

It is not the intent of the Committee that this information should in any way limit debate or discourage the exploration of alternate methods of flood control. The Committee has given careful consideration to all plans which have been presented and will continue this policy. However, the basic principles of flood control must be understood, the magnitude and complexities of the problem must be appreciated and the need for cooperation of all portions of the basin must be accepted before flood control can be realized in the Passaic Valley.

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## INTRODUCTION

The Passaic River has long been recognized as the most important flood problem in the State of New Jersey. The major floods of 1902 and 1903 emphasized the need for action to prevent or minimize future damages. To that end, at least seven detailed engineering reports recommending practical solutions to the problem have been issued during the past 52 years. None however, has been acceptable to all interests of the basin, while year by year the solution becomes more difficult as the number of persons and value of property subject to flooding continues to increase at an alarming rate.

In June of 1953, former Governor Alfred E. Driscoll appointed a special Passaic Valley Flood Control Committee at the request of the counties of Morris, Passaic and Essex and the Passaic Valley Flood Control Association representing most of the effected municipalities of the Lower Valley. Committee members, representing all portions of the basin were appointed from nominations submitted by the Boards of Chosen Freeholders of Morris, Essex, Passaic and Bergen Counties. Governor Robert B. Meyner, aware of the seriousness of the Passaic River flood problem has continued the Committee with its original membership during the present administration.

The Committee's assignment is to investigate and report on the practicability of developing an equitable plan for the control of floods in the Passaic Valley which will be acceptable to a majority of local interests, provide a reasonable amount of channel enlargement and a reasonable amount of detention storage and satisfy the design requirements of the U. S. Corps of Engineers. Questions pertaining to the cost of the project and to justification on the basis of benefits to be derived are to be deferred for the review and analysis of the U. S. Corps of Engineers when and if an acceptable and satisfactory plan is developed for submission to Congress.

The Committee has been assisted in their investigations by engineers of Bergen, Essex, Morris and Passaic Counties and the Division of Water Policy and Supply of the State Department of Conservation and Economic Development. Services of consulting engineers were secured with funds appropriated by the State of New Jersey and the counties of Essex, Morris and Passaic to provide additional surveys and engineering data needed for the Committee and local interests to determine the acceptable limits of detention basin storage in the Upper Passaic Valley and the practicability of enlarging the channel and deepening the stream bed to increase the flood carrying capacity of the Lower Passaic River.

## DESCRIPTION OF BASIN

The Passaic River watershed is an oval-shaped area of some 935 square miles of which 84 percent is located in and adjacent to the metropolitan area of the northeastern portion of New Jersey, and the remainder in southern New York State.

The major tributaries of the upper basin are the Pompton River which is formed by the Pequannock, Wanaque and Ramapo Rivers and flows south to its junction with the Passaic River at Two Bridges, and the Whippany and Rockaway Rivers which join the upper river at Pine Brook. Below Two Bridges, numerous smaller tributaries join the Passaic River, the largest and most important being the Saddle River.

The drainage basin may be divided into the following three natural divisions having widely different topographic and hydrologic characteristics:

1. **The Highland Region** is a mountainous area 10 to 15 miles wide at an average height of 1,300 feet above sea level which is characterized by a series of parallel ridges flanking the westerly and northerly limits of the drainage basin. These ridges are deeply dissected by a series of steep-sided transverse valleys in which flow the Ramapo, Wanaque, Pequannock, Rockaway and Whippany Rivers and the upper limits of the Passaic River, which are extremely flashy in their run-off.
2. **The Central Basin** is a crescent-shaped, broad, flat valley, 8 to 12 miles wide and approximately 30 miles long, which lies between the Highland Region and the Watchung Mountains to the south and east, and which extends from Great Swamp on the south through Chatham to Pompton Lakes in the Pompton Valley on the north. The upper Passaic River enters the Central Basin from the southwest, and after following a meandering general northerly and easterly course through low-lying and marshy lands, leaves the Basin through the gorge at Little Falls. The Highland Region tributaries discharge their flows into the Central Basin within a short distance of each other.
3. **The Lower Valley** is that portion of the watershed lying between the Central Basin and the river mouth at Newark Bay and includes the tidal estuary which extends to within a few hundred feet of Dundee Dam. The river gradient is flat but broken by falls at Little Falls, Great Falls and Dundee Dam. From Great Falls to Dundee Dam the drainage basin is relatively wide.

The Passaic River has a unique drainage system which is the result of the mighty forces which nature exerted during the last Ice Age in changing, not only the direction of flow of the Passaic River, but the entire character of the drainage basin. Prior to the last glacier which at one time covered northern New Jersey and practically all of the present drainage area, geologists advise that the Passaic River, including its major tributaries, the Whippany, Rockaway and Pompton Rivers flowed south through a notch in the Watchung Mountains in the vicinity of what is now Short Hills and thence, east to the Arthur Kill between Newark and Elizabeth. At that time, the lower Passaic River through Paterson and Newark must have been a small stream with headwaters in the vicinity of Little Falls. The glacier in its advance southward eventually reached and permanently closed the Short Hills gap, thus impounding waters which formed a great lake between the face of the advancing glacier and the curve of the Watchung Mountains to the south. The lake level continued to rise until an outlet to the Raritan River was provided at Moggs Hollow near Pluckemin. As the glacier retreated to the northward, the lake known as prehistoric Lake Passaic, increased in size and continued to discharge through the Moggs Hollow Gap until the present outlet was uncovered through the Watchung Mountains at Little Falls. This outlet, though considerably lower in elevation than the pass at Moggs Hollow, is at a higher elevation than the original outlet at Short Hills. The net result was to add some 740 square miles of drainage area to the headwaters of the originally small stream which is now known as the lower Passaic River and to create, within the limits of the former glacial lake, a natural detention basin of some 12,000 acres of swamp and marsh lands, plus some 6,000 acres in Great Swamp upstream of Chatham, to sustain low flows and suppress flood peak discharges on the lower river. Thus, in effect, this portion of the Passaic River basin consists, under present conditions, of a large, rapidly developing central basin north of Chatham covering some 18,000 acres of land subject to flooding which is connected to a tidal estuary off Newark Bay by an inadequate natural channel located through a highly developed but older industrial and residential area in which the flood plain subject to flood damages is limited to some 4700 acres.

#### **THE FLOOD PROBLEM**

The major problem of the Passaic watershed which is the subject of the Committee's investigations, is located in the Central Basin to the north of Chatham in the Black and Troy Meadows areas of Morris County, the Great Piece and Passaic meadow areas of western Essex County and the Pompton Valley area in Morris and northern Passaic counties and also along the main channel and tidal

estuary of the lower river between Passaic, Bergen, Essex and Hudson counties. The point of demarcation between the Central Basin and lower Passaic River is usually located at Two Bridges where the Pompton River joins the Passaic River and the county lines of Morris, Essex and Passaic intersect.

While flood problems exist on some of the upper tributaries such as in the Great Swamp and vicinity on the upper Passaic River, the Denville area along the Rockaway and the Oakland Valley on the Ramapo River, these problems like similar ones on the tributaries of the lower river can be solved without too great difficulty once a satisfactory solution has been obtained to the major problem.

Because of the natural characteristics of the drainage basin, the basic engineering problem is relatively simple, both as to cause and solution. The location of the Central Basin between the Highlands and the Lower Valley and the large areal extent and bowl-shaped topography of that basin present most favorable hydrologic and topographic conditions for the effective control of floods on the Lower River, which has only an average bankfull capacity of some 7,000 cubic feet per second. Because of the location, the storage provided naturally in the Central Basin is more highly effective in equalizing and suppressing the flood run-off from the Highlands than a corresponding equal volume of combined storage located on the upland tributaries. The Central Basin, therefore, provides a tremendous amount of natural detention storage which cannot be sacrificed without greatly increasing flooding in the Lower Valley.

For instance, for the maximum flood of record of October 1903, the Central Basin provided some 40 billion gallons of natural storage to suppress the estimated inflow peak rate of 46,000 cubic feet per second to 31,700 cubic feet per second as observed at Little Falls downstream of the basin. The basin also provides most favorable topographic conditions for increasing the natural storage facilities by the construction of a dam and other control works in the vicinity of Two Bridges to suppress the 1903 flood inflow rate to between 12,000 and 14,000 cubic feet per second at Little Falls. While this suppression is of great value to the entire lower valley, it is of prime importance to the highly industrialized area along the tidal estuary where flood levels are controlled by high tides and cannot be lowered appreciably except by the suppression of flood peak discharge.

The complications which have prevented any acceptable solution, however, are the result of economic and social rather than engineering problems which were created by the location of the Central Basin on the fringe of a rapidly expanding, highly developed

metropolitan area, and the desire of the residents of that basin for their communities to experience the same high degree of development as their neighbors outside the basin. Moreover, the favorable balance between the amount of benefits to be derived by protecting the relatively narrow but highly congested flood plain of the lower river at the expense of flood plain clearance and land restrictions in the Central Basin is rapidly approaching and may have passed the point of economic and social justification. Industry, once dependent on the river for power, water supply and transportation, now has a tendency to move away from the congested centers of population as needs are provided in better quality and quantity at more favorable locations. On the other hand, development of the lowlands of the Central Basin has increased the cost of lands required for the satisfactory protection of the lower river, and has decreased the possibility of providing a practical solution to the problem. Moreover, the problem now involves the protection of not only the older, more highly developed lower valley but also substantial portions of the Central Basin, especially in the Pompton Valley.

### FLOOD HISTORY

Continuous records of flow of the Passaic River have been available since January 1877, and historical records and observations provide valuable information on floods which occurred during a period of some hundred years prior to this date.

TABLE 1

#### MAXIMUM FLOODS OF RECORD AT GREAT FALLS, PATERSON

<u>Date</u>	<u>Peak Discharge</u> <u>Cu.Ft./Sec.</u>	<u>Date</u>	<u>Peak Discharge</u> <u>Cu.Ft./Sec.</u>
October 10, 1903	34,000	January 3, 1888	11,880
November 24, 1810*	27,000	January 24, 1891	11,700
July 17, 1865*	22,500	March 14, 1893	11,240
March 2, 1902	22,500	May 6, 1893	11,160
<u>July 23, 1945</u>	19,500	December 23, 1902	11,400
<u>March 13, 1936</u>	19,400	September 21, 1888	11,130
September 25, 1882	18,260	December 31, 1901	11,000
February 8, 1896	17,220	<u>April 8, 1924</u>	11,000
December 12, 1878	16,590	<u>April 29, 1889</u>	10,970
February 14, 1886	12,450	<u>March 17, 1912</u>	10,950
<u>April 1, 1951</u>	12,400	<u>March 29, 1877</u>	10,780
<u>March 18, 1920</u>	12,300	March 4, 1896	10,500
<u>June 3, 1952</u>	12,000	April 8, 1886	10,420

\*From Historical Records

As indicated by Table 1, floods do not occur at regular intervals of time. Of the 24 greatest floods which have been experienced during the 78-year period of record, seventeen occurred during the first 27 years and only the seven, underlined and shown in their order of magnitude above, were experienced during the 51 years subsequent to that period. This unusual distribution of floods indicates that the Passaic River basin has been extremely fortunate during recent years. Eventually, however, the law of averages must be satisfied and more floods of greater magnitude can be expected in the future. The hydrologist cannot predict the date of occurrence of a flood, but he is able to estimate within reasonable limits, the minimum magnitude of flooding which can be expected, on the average, in any period of time by analyzing the record of past floods. While the flood of October 1903 is unusual and can be expected only at very rare intervals, a flood equal to or greater than this maximum flood of record is possible in any year and will certainly occur at some time in the future.

A map of the Passaic River basin showing the extent of flooding in October 1903 and a summary table of flood high water experienced in the Upper Valley in 1903, 1936, 1945 and 1951 are shown in Appendix B.

### **FLOOD HYDROLOGY**

Major floods are the result of many complicated hydrologic factors such as the intensity, duration and distribution of rainfall, the direction of travel of the storm, the saturation of the ground from previous rainfall, the season of the year, the amount of melted ice and snow contributing to the flood run-off and in the lower reach of the river, the height of tide. Heavy rainfall, in itself, usually results in a major flood only when it occurs simultaneously with one or more other conditions favorable for excessive run-off. Topographic characteristics of the watershed which control the speed in which run-off is concentrated and the timing of the tributary flood peaks in reaching the main stream channel are factors which determine the magnitude and duration of flooding. During any major flood, especially those floods of greater than design magnitude, unexpected events such as dam or dike failures, ice jams, and blocked bridge openings may be experienced which may greatly effect the magnitude of the flood heights in local areas.

Along the tidal estuary of the lower Passaic River the amount of flooding depends primarily upon the height of tide at the time of the flood peak. It may be of interest to note that by far the greatest tides of record have been experienced during recent years, and that even higher tides can be expected in the future. Moreover, hurri-

canes which are the critical type of storm for the Passaic River basin and are usually accompanied by high tides and heavy rainfall, appear to be more prevalent in this area than in the past. Should a hurricane be experienced after a period of prolonged rainfall which has thoroughly saturated the ground, the coincidence of heavy run-off and high tide would cause extremely heavy damage in the tidal estuary of the lower Passaic River.

The natural hydrologic characteristics of the Passaic basin have not been changed appreciably by either the encroachments which have reduced to some degree the natural, limited capacity of the lower river channel or the changes in land use resulting from the de-forestation and development in the upper basin. The construction of water supply reservoirs on the upland tributaries is a factor which may have a limited affect in reducing minor floods during periods when the storage in the reservoirs is below spillway level. For the major floods, however, records indicate that such reservoirs would have been filled to capacity by the heavy antecedent rainfalls which normally proceed such floods, and that the effect of storage above spillway level would be insignificant. As shown by Table C1, Appendix C, all except one of the eight greatest floods of record which were studied, occurred subsequent to an above normal period of precipitation. Moreover, the effectiveness of the storage in reducing flood peak discharges is limited by the relatively small percent of the total watershed which the reservoirs control. Similarly, local drainage and stream clearance projects which in many instances may alleviate local damages caused by minor floods, will have no appreciable effect on major floods.

#### **THE DESIGN FLOOD**

The degree of protection to be provided by a flood control project is determined by the size of the design flood. Complete protection against the maximum possible flood is seldom attainable because of practical and physical limitations. Moreover, except in rare instances where there is considerable hazard to life, or damage to certain highly congested key industrial areas would be excessive, can complete protection be justified for economic reasons, such as the ratio of benefits to cost and the financial ability to pay. On the other hand, partial protection against floods of lesser magnitude involves a calculated risk as to the amount of damage and probable frequency of such damage from floods which exceed the design capacity of the control works. Unless the extent of this calculated risk is fully appreciated by the area protected, and proper allowances are made for the limited degree of protection, partial flood control may be worse than no flood control.

On small streams where hazard to life and extent of damage resulting from floods in excess of design is not severe, it is standard practice to accept more of a calculated risk and provide protection for a flood considerably less than maximum.

For a project of the magnitude of that proposed for the Passaic Valley, however, the design flood must be equal to or exceed the greatest flood of record and preferably approach the greatest flood which can reasonably be expected to occur in the basin. Providing only partial protection for a flood of lesser magnitude would involve calculated risks and responsibilities which no governmental agency or responsible authority could afford to assume.

In view of the magnitude of a flood control project for the Passaic Valley, and in consideration of the U. S. Corps of Engineers' standards which must be met for Federal participation, a design flood 10 percent greater than the flood experienced in 1903 is the minimum which the Committee can consider for their investigations. This requirement will increase the detention basin flow line elevation approximately 1.5 feet above that needed for a design flood equal to that of October 1903.

#### **FLOOD CONTROL METHODS**

Protection against floods can be provided by any of the following four methods or combinations thereof:

1. Improvement or enlargement of stream channels to increase their capacities sufficiently to pass flood flows without causing damage.
2. Construction of storage or detention basins which temporarily hold back flood flows in excess of the capacity of the design channels.
3. Raising lowlands above flood heights or diking such lands and providing tide gates and emergency pumping stations.
4. Removal of buildings and other improvements from low areas subject to flooding, thereby eliminating the necessity for protection.

The first of these methods is a man-made device which, without proper planning may provide only temporary local protection and increase flood peak discharges beyond practical control limits elsewhere in the basin. The flood carrying capacities of channels may be increased; first, by increasing the cross-sectional area of the waterway by widening, deepening the stream bed, and removing obstructions to flow; and second, by increasing the velocity of flood flows by steepening the slope of the stream bed and by wall-

ing, paving or otherwise smoothing the channel cross-section to reduce friction to flow.

The second is Nature's way of handling the problem but requires restrictions to the use of lands within the basin sites. Under normal conditions detention basins are dry and the lands may be used for recreation and other purposes. During floods the basins fill, the depth of water depending on the magnitude of the flood. After flooding, the basins are dewatered as soon as possible to provide a maximum storage for subsequent floods.

The third is expensive but can be justified when the value of the property protected exceeds the cost of the local protective works and the protection does not adversely effect flood conditions elsewhere. This method provides protection not only for lands adjacent to improved channels, but also for the property which is of sufficient value to be deleted from the detention basin site.

The fourth method, flood plain clearance, is often strenuously opposed locally, but in many instances provides the most economical and equitable means of protection. Usually it is found that most of the structures which are removed from the flood plain are sub-standard buildings which have adversely effected the normal, healthy growth of the entire community. Eventually all properties located in flood areas will be damaged or otherwise adversely affected so as to become a liability to the community.

#### APPLICABILITY OF METHODS TO PROBLEM

*The Lower Passaic River*—Any practical plan of flood control must provide for extensive and expensive channel improvement to increase the flood carrying capacity of the lower Passaic River. Investigations have indicated that it is practicable to more than double the present capacity of the lower river from Two Bridges to Dundee Dam to provide for a flood discharge of 16,000 cubic feet per second at Dundee Dam by deepening the stream bed, widening narrow reaches, walling low areas, reconstructing and raising inadequate bridges and installing gate controls at the dams at Little Falls and Great Falls. While additional channel improvements to provide protection against a flood of 18,000 cubic feet per second may prove to be feasible, further increase in channel capacity would greatly increase the cost of the project and destroy flood control benefits which must be realized if flood control is to be economically justified by a favorable cost-benefit ratio.

In the tidal estuary downstream of Dundee Dam, the magnitude of flooding is controlled by the height of tide occurring at the time of the flood peak. Channel enlargement under this condition is not effective, and would only result in slight reduction in flood high

water in the upper portion of the reach below Dundee Dam. While walling and diking and raising lowlands to protect critical areas below Dundee Dam will be necessary, reduction in flood peak discharge on this portion of the river is the only practicable means of reducing flood heights along the navigable reach of the river. The Summary of the report prepared by Mr. Russell S. Wise, consulting engineer of Clifton, New Jersey, regarding his investigations of the lower river has been included as Appendix D. Also included in Appendix D is Plate D1, showing comparative costs for providing various flood discharge capacities on the lower river.

*The Central Basin*—Under present conditions, the lowlands of the Central Basin provide a natural detention basin for impounding flood waters. The effectiveness of this natural storage in reducing flood discharges in the lower Passaic Valley may be readily appreciated during any major flood. Without this upland storage it has been estimated that the peak discharge of 33,700 cubic feet per second which was experienced in Paterson during the flood of October 1903 would have been increased to some 52,000 cubic feet per second. Inasmuch as the practical range for channel design of the lower Passaic River is considered to be 16,000 to 18,000 cubic feet per second, for a flood equal to or greater than the October 1903 flood it is apparent that the existing storage of the Central Basin must not only be maintained, but increased and used more effectively. Except for certain portions of the Central Basin for which protection by walls and diking can be economically justified, flood plain clearance by removal of structures and restriction of land use within the detention basin site is the only practical solution to the flood problem.

Due to the increased construction in the Central Basin, particularly in recent years, any practicable plan of flood control for the Passaic Valley should now consider not only for protection of the highly-developed lower valley, but also for substantial portions of the upper Passaic Valley as well. Protection for the entire Pompton Valley is possible and should be given primary consideration. The Community of Lake Hiawatha, the Commonwealth Reservoir Area, and the Morristown Airport are other areas which have in the past been considered of sufficient value to warrant protection. In addition, a detailed investigation of the fringe area should be undertaken by each community to determine the property which can be economically protected against flood damage by raising structures and lands above flood heights or by protective walls or dikes. It should be appreciated, however, that the loss of storage from the protection and landreclamation in one portion of the detention basin will have to be compensated by increasing the flood high water elevation elsewhere, and that reclamation can only be considered

practicable where benefits to be derived exceed the cost of the protection works.

Delineation of areas of the Central Basin for protection or reclamation is a problem which can best be solved at a local level by those directly concerned with the problem. To assist in the determinations, contour maps of each municipality have been prepared to serve as a basis for defining the limits of an acceptable detention basin.

#### FLOOD CONTROL PLANS CONSIDERED

Particular emphasis was placed on the study of the effectiveness of three plans for the development of detention basin storage in the Central Basin which are discussed below, summarized in Table 2 and shown in Appendix E. In accordance with Corps of Engineers standards, a taking line which is three feet above the design flow line was selected to define the limits of the detention basin.

*Two Bridges Reservoir*—This plan, shown by Plate E1 of Appendix E, to construct a dam below Two Bridges to impound all inflow from the upper Passaic, Whippany, Rockaway and Pompton Rivers and their tributaries in a central basin will provide the degree of flood suppression necessary for a solution to the Passaic River flood problem. While a minimum flow line elevation is required by this plan, no protection is provided for the Pompton Valley. No consideration was given for including a permanent pool for water supply or recreational purposes. As shown in following Table 2, an average *taking line* from El. 181.5 to El. 182.5 would be required to reduce the design flood to the range considered practical for protection of the lower Passaic Valley.

*Modified Two Bridges*—This plan shown by Plate E2 of Appendix E provides for the construction of a dam above Two Bridges and the protection of the entire Pompton Valley by the construction of a Pompton River diversion channel through Hook Mountain to a central detention basin. While this plan does not provide the volume of storage which would be made available by adoption of the Two Bridges Reservoir Plan and would increase by approximately 1.5 feet the flow line required in other portions of the detention basin site, the plan has the advantage of providing flood protection for the more highly developed areas of the Pompton Valley by extending diking upstream of the diversion channel. As shown in Table 2, an average *taking line* from El. 183.0 to El. 184.0 would be required for practicable flood suppression.

**TABLE 2**  
**PASSAIC RIVER FLOOD CONTROL**  
**COMPARATIVE SUMMARY TABLE OF SUPPRESSED FLOOD PEAK DISCHARGES**  
**FOR VARIOUS DETENTION BASIN HIGH WATER ELEVATIONS**  
**DESIGN FLOOD OF OCTOBER 3, 1903 + 10%**

Plan	Flow Line		Area Sq. Miles	Storage Billion Gals.		Flood Discharge-Cubic Feet per Second		
	Elev.	Taking Line Elev.				Two Bridges	Great Falls	Dundee Dam
Two Bridges Reservoir	172.0	175.0	21.1	26.6		29,200	32,000	34,500
	173.0	176.0	23.1	31.0		25,300	28,800	31,300
(Dam downstream of Two Bridges with flooding of Pompton Valley)	174.0	177.0	25.0	35.6		21,800	23,800	28,300
	175.0	178.0	27.0	41.0		18,500	23,100	25,600
	176.0	179.0	29.0	46.8		15,500	20,600	23,100
	177.0	180.0	30.7	52.7		12,600	18,400	20,900
	178.0	181.0	32.3	58.8		10,000	16,300	18,800
	179.0	182.0	34.1	65.3		7,500	14,400	16,900
	180.0	183.0	35.5	72.5		5,200	12,800	15,300
Modified Two Bridges Reservoir	173.0	176.0	20.0	24.2		30,000	33,000	35,500
	174.0	177.0	21.5	28.8		26,300	30,000	32,500
	175.0	178.0	23.0	33.7		22,800	27,200	29,700
(Dam upstream of Two Bridges with protection of Pompton Valley)	176.0	179.0	24.4	39.1		19,500	24,500	27,000
	177.0	180.0	25.6	44.0		16,500	22,000	24,500
	178.0	181.0	27.0	50.0		13,800	19,800	22,300
	179.0	182.0	28.3	55.4		11,200	17,600	20,100
	180.0	183.0	29.5	61.5		8,800	15,700	18,200
	181.0	184.0	30.3	67.5		6,700	13,900	16,400
	182.0	185.0	31.1	74.0		4,900	12,200	14,700
Crater Plan*								
Fairfield Lake								
Pool at Elev. 170.0	184.5	187.5	5.5	16.2		44,800	52,800	55,300
Without permanent pool	184.5	187.5	5.5	23.8			40,400	42,900
Troy Lake (Pool at El. 173.0)	190.0	193.0	4.1	14.4				
Total (with Fairfield Lake Pool)				30.6				
Total (without Fairfield Lake Pool)				38.2				

\*Complete land reclamation above Little Falls except for  
Fairfield Lake and Troy Lake Basins

*Crator Plan*—This plan, which Mr. Ronald D. Crator, Chief Engineer of the Essex County Park Commission, developed in detail and presented to the Committee for consideration, illustrates the interest of the local engineers of the basin, their knowledge of the problems involved, and their efforts to develop a practical plan of flood control in the Passaic Valley. While the plan is sound in principle, and would undoubtedly win the greatest support of all interests of the Upper Valley, it unfortunately will not provide the degree of suppression required for a practical solution to the flood problem.

In general the plan as shown by Plate E3, Appendix E provides for the development of two multiple purpose basins with permanent pools for recreation and freeboard for flood storage—Troy Lake in Troy Meadows to control the Rockaway River, and Fairfield Lake in Great Piece Meadows to store flood flows from the Pompton River. Except for the proposed 5.5 square miles in Fairfield Lake and the 4.1 square miles in Troy Lake, the plan recommends channel improvements to drain and provide flood protection for all other portions of the Upper Valley, including the entire Pompton Valley.

While the proposed Troy Lake basin is adequate to completely store the entire design flood run-off from the Rockaway River and the Fairfield Lake basin is capable of reducing the Pompton River design peak discharge of 38,400 cubic feet per second to some 27,000 cubic feet per second with the permanent pool and to 15,000 cubic feet per second if the entire basin were made available for flood storage, the flood discharge downstream at Great Falls in Paterson, as shown in Table 2 would be considerably greater than the 37,100 cubic feet per second which can be expected if a design flood were to be experienced under present natural conditions. Both basins include extensive dikes of considerable magnitude which together with the proposed channel improvements would increase the difficulty of economic justification.

In addition to the three plans discussed above, the Corps of Engineers have investigated the following plans. Peak discharges were adjusted to conform with the same design flood conditions selected for analysis of the Two Bridges Reservoir, Modified Two Bridges Reservoir and Crater Plans.

- (a) *Meadowland Reclamation* of the upper Passaic River by channel improvements and fill which would result in loss of all natural storage except for that in Troy Meadows—57,000 cubic feet per second at Great Falls, Paterson.

- (b) *Oakland and Whippanong Reservoir Plan* to develop two detention basin sites; the Whippanong Reservoir to control flows from the Whippany and Rockaway Rivers above their junction at Pine Brook and the Oakland Reservoir to control floods of the Ramapo River above Oakland—22,400 cubic feet per second at Great Falls, Paterson.
- (c) *Existing Conditions* which were assumed in 1948 to provide the same amount of natural flood storage as in October 1903,—37,100 cubic feet per second at Great Falls, Paterson.

*Upland Tributary Storage*—Consideration was given to detention basin storage on the upland tributaries above the Central Basin. Inspection of the tributary areas, however, indicates that no sites are available which could be practicably developed to replace or appreciably reduce the volume of storage required in the Central Basin.

The only site which produces sufficient storage and controls sufficient drainage area to warrant detailed investigation is the Oakland site on the Ramapo River which has been studied previously by both Special Report No. 2 of the N. J. State Water Policy Commission and the U. S. Corps of Engineers. The use of this site would involve the construction of a dam approximately 500 feet in length with a maximum height of 89 feet to impound flood waters on high lands well above the present flood plain of the Ramapo River.

Another site of sufficient area is Great Swamp above Millington on the headwaters of the Passaic River. However, the drainage area which would be controlled by this site, is insufficient to warrant consideration. Similarly, a detention basin could be considered in the Upper Longwood Valley of the Rockaway River but again the controlled area is too small and the use of this valley would destroy an existing recreational area and a valuable potential water supply reservoir site. Suitable sites on the Wanaque and Pequannock Rivers are now developed as water supply reservoirs which cannot be enlarged to provide freeboard for flood storage for topographic reasons.

The Committee will be pleased to investigate all upland tributary storage sites which are considered of sufficient value to warrant a more detailed study.

*Excavation and Fill*—At the request of engineers of the upper Passaic Valley, the practicability of providing storage by excavation and use of the material removed as fill to reclaim lowlands was

investigated. However, it was realized that the cost and complications of excavating, transporting and spreading up to distances of 20 miles sufficient material to provide even a small portion of the 60 to 70 billion gallons of storage required cannot be justified by land reclamation benefits. When it is realized that the 60 to 70 billions of gallons of storage required is considerably greater than the total volume of material excavated for the Panama Canal, and that such a quantity may be visualized as a block 275 feet in height over an area of one square mile, the magnitude of the storage required may be more fully appreciated.

## FEDERAL FLOOD CONTROL REGULATIONS

### Design Flood

Under existing Army Engineers' standards the following floods must be considered in justifying a flood control project.

- a. *Standard Project Flood* is a flood which would be exceeded in magnitude only on rare occasions. In most cases, it would equal or approximate the flood which would result under existing or specified conditions of basin development, if the critical storm of record of the region should occur over the drainage area involved when hydrologic conditions were reasonably favorable for flood run-off. It, therefore, constitutes a standard for design of structures which would provide a high degree of flood protection as determined by flood potentialities of the drainage area involved, *without regard to localized economic or other practical limitations of the project*. The Standard Project Flood used in the 1948 Survey Report of the Passaic River was approximately 50 percent greater than the 1903 flood at Great Falls, Paterson.
- b. *Design Flood*—Although the standard project flood represents the objective toward which the design of flood protection works is ordinarily directed, topographic and economic limitations may not permit the complete attainment of this objective. The flood against which protection is actually provided under any given plan, designated as the design flood, represents the maximum practical degree of protection which can be provided, and is ordinarily less than the Standard Project Flood. The Design Flood used in the 1948 Survey Report was approximately 20 percent greater than the 1903 flood at Great Falls, Paterson.
- c. *Maximum Probable Flood*—The maximum probable flood represents the largest flood which might occur in nature if

the worst conditions of rainfall, ground saturation and storm position were to occur coincidentally. For the 1948 Survey Report this flood, which was approximately 150% greater than the 1903 flood, was used, primarily, for the design of the dam spillway.

As discussed earlier in this report, the Committee has selected a design flood equal to the 1903 flood plus 10%. This flood approaches the design flood used by the Corps of Engineers in their 1948 Survey Report of the Passaic River and is considered the minimum size flood which would be acceptable to the Corps of Engineers for Federal participation in a flood control project.

**Use of Detention Basin Lands**—The use which will be permitted of the lands located within detention basins is being restudied by the Corps of Engineers. It is understood, however, that at the present time all lands within the taking line, which can be assumed to be approximately three feet above the design flow line, will be controlled preferably by securing flowage easements or by direct purchase where a hardship exists. Within this area all permanent structures must be raised above the taking line elevation, removed or demolished. In special instances, however, barns and other structures not used for human habitation may be permitted in the upper limits of the restricted area.

Since flood records show that floods in the Passaic Valley are rare during the summer months, maximum use of the land for recreational purposes, farming and grazing should be considered.

**Requirement for Justification**—All flood control projects in which the Federal Government participates must meet the basic requirement that the benefits to be derived from the project must equal or exceed the cost of the project. In many instances, flood control, in itself, cannot be economically justified and must be supplemented by incorporating additional multiple purpose features such as water supply, water power or navigation. Inasmuch as a multiple purpose project is not being considered for the Passaic Valley, justification must be based primarily on flood control benefits and the collateral by-product benefits incident to flood control.

#### **Allowable Benefits**

Benefits allowable by the Federal government in justification of a flood control project are as follows:

(a) Benefits directly attributed to prevention of flood damage and losses such as:

1. Direct physical destruction of property within the flood area, and

2. Loss of business within and outside of the flood area, loss of wages, increased transportation costs, costs of rescue, cost of relief and emergency protective operations and miscellaneous other losses directly resulting from floods.

(b) Collateral Benefits

1. Water supply benefits which would accrue by the construction of a multiple purpose reservoir with a permanent pool for water supply storage and freeboard for flood storage. Since water supply is not being considered as part of the Passaic Valley flood control plan, no benefits will be derived from this source.
2. Abatement of stream pollution benefits which would accrue by increasing low water flow of the lower river. Inasmuch as a multiple-purpose reservoir is necessary for low flow regulations, no stream pollution benefits will be derived.
3. Water power benefits may be realized by either power generation at the dam site or by regulation of low flow for power generation downstream. No water power benefits will be derived by construction of the proposed flood control detention basin.
4. Improvement to navigation is a benefit which is derived by the improvement of navigable channels. Benefits will be realized by the proposed widening and deepening of the navigable channel below Dundee Dam.
5. Mosquito control benefits are derived by the drainage or flooding of swamp lands and other mosquito abatement improvements. As the proposed plans provide for lowering the hydraulic control at the dam site which will permit partial drainage of Great Piece Meadows, some benefits will be realized.
6. Enhancement of land values are benefits which accrue to upland property by improvement of the flood area by such means as the creation of permanent lakes within the flood plain and slum clearance. While the proposed project will permit improvement of protected areas which were subject to frequent flooding and beautification of lands and construction of small recreational ponds within the detention basin site which eventually will be reflected in increased upland values, these benefits are not considered a direct result of flood control.

- (c) Intangible benefits are benefits which cannot be evaluated in terms of dollars and cents such as the preservation of

the meadow lands of the upper Passaic Valley as a wild life refuge and removal of the hazard of possible heavy loss of life.

#### **LAND RECLAMATION**

While land reclamation is usually an important by-product of flood control, neither its added cost or the benefits to be derived may be considered in justification of a Federal flood control project. Under Federal regulations all benefits must be based on the actual conditions which exist at the time the project is authorized. However, a practicable plan of flood control will permit land reclamation throughout considerable portions of the Passaic Valley and the value of future benefits which reclamation will develop in not only the areas which have been provided with flood protection but in the Passaic Valley, as a whole, should be thoroughly investigated. While land reclamation costs must be borne locally, the value of the direct and intangible benefits to be derived by the normal, healthy development of areas previously blighted by frequent flooding and the uncertainty of the future, should not be underestimated.

#### **BENEFITS OF COMPROMISE PLAN**

As a new and rather unique approach to the problem of flood control, the people of the Passaic Valley have been requested to develop a plan which, by compromise, will lessen the burden which previous plans have imposed on certain portions of the basin, and provide for a more uniform distribution of benefits throughout the entire area. This is a sensible and practical procedure which emphasizes the social aspects of the problem for the first time and leaves the final decision regarding the solution to the problem directly with the people concerned.

It must be appreciated, however, that any plan for flood control which is acceptable to the Passaic Valley must also be economically justified by meeting the basic requirement that the benefits derived are in excess of the cost of the project. Unfortunately, due to the character of the basin, flood control benefits cannot be evenly distributed throughout the entire Passaic Valley as primary consideration must be given to the protection of areas which will provide the most favorable cost-benefit ratios.

In the past most plans provided only for the protection of the older highly developed lower valley. Today, large portions of the flood plain of the Central Basin must be provided with the same degree of protection as the lower valley, and the resulting loss of natural storage must be compensated for by increasing design high water flow lines elsewhere in the Central Basin.

For much of the Central Basin and the lower valley above Dundee Dam the proposed plan will provide complete flood protection up to the limits of the design flood. Along the tidal reach below Dundee Dam where complete protection is not possible due to tidal backwater, flood damage will be alleviated by reduction of flood discharges.

In that portion of the Central Basin which is reserved for detention storage, flood damage will be prevented up to the limits of the design flood by flood plain clearance, except for the risk involved by the limited use of the flood plain. It should be appreciated that much of the detention basin site consists of swamp lands which are unusable or of areas in the flood plain which are subject to frequent flooding. In many instances it will be found that the buildings to be removed from the flood plain are substandard structures which are a detriment rather than an asset to the community. However, in all cases where individuals, municipalities or counties suffer initial losses within the limits of the detention basin site which are in excess of benefits received, the compromise plan must provide for adequate compensation.

#### **ALTERNATE SOLUTIONS**

It is apparent to all who have studied the Passaic River problem that the continued development of areas subject to flooding and the refusal by the people of the basin to face the situation by providing effective flood control measures can only result in a major disaster and eventually create a situation which will be impossible to remedy.

If it is found that a compromise flood control plan is not acceptable or cannot be economically justified, the Passaic Valley must rely primarily on preventive rather than protective measures for obtaining partial flood relief. Steps to assure maintenance of the present natural storage of the Central Basin and legislation to prevent further encroachments on the flood plains of both the upper and lower valleys should be given primary consideration. Flood plain clearance should then be undertaken in an orderly manner in all areas which are subject to frequent flooding. The protection of key industrial areas of the lower valley by the construction of walls and dikes might be practicable. However, such protection would prove to be extremely costly and could be justified only in limited areas. In the upper Passaic Valley alleviation of damages caused by frequent small floods could probably be accomplished by stream clearance programs. These projects, however, would have little effect in reducing major flooding in the upper valley.

## **APPENDIX A**

### **BIBLIOGRAPHY**

#### **OF**

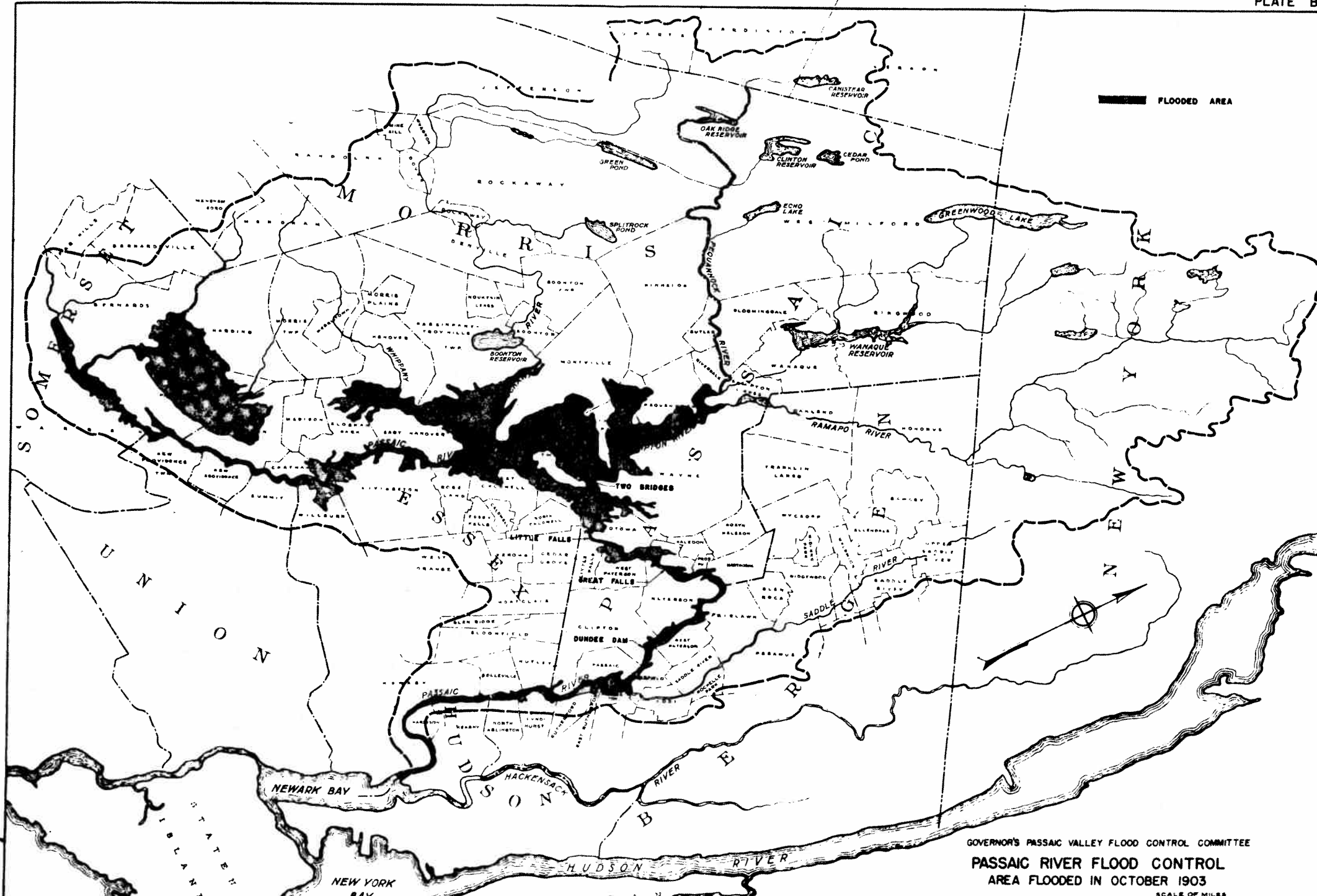
### **PASSAIC RIVER FLOOD CONTROL REPORTS**

1. 1902 Report on the Flood of February 1902, by C. C. Vermeule, Annual Report of State Geologist
2. 1903 Report on the Floods of October 1903 -- Passaic Floods and Their Control, by C. C. Vermeule, Annual Report of State Geologist (Proposed reservoir with dam at Little Falls)
3. 1904 Report of the Northern New Jersey Flood Commission (Proposed reservoir with dam at Mountain View)
4. 1906 Report of the Passaic River Flood District Commission (Detailed study for dam at Mountain View)
5. 1928 Report on Control of Floods and Drainage of Wet Lands in the Valley of the Passaic River and its Tributaries, by C. C. Vermeule, Department of Conservation and Development (Proposed Whippanong Reservoir and extensive channel improvements)
6. 1930 Report of the Commission on Flood Control by Allen Hazen (Review of earlier reports)
7. 1931 Special Report No. 2, Control of Floods on the Passaic River, State Water Policy Commission (Review of earlier reports)
8. 1937 Report of the Passaic Valley Flood Control Commission (Proposed Whippanong Lake Project)
9. 1938 Survey Report, New York District, U. S. Corps of Engineers (Review of earlier reports)
10. 1948 Survey Report, New York District, U. S. Corps of Engineers (Proposed multiple-purpose reservoir above Two Bridges)

**TABLE B1  
SUMMARY TABLE  
FLOOD HIGH WATER ELEVATIONS  
UPPER PASSAIC RIVER BASIN**

Municipality	Locality or Name of Bridge	Flood Elevation at Bridge			
		1903	1936	1945	1951
UPPER PASSAIC RIVER					
Caldwell	Route 6	172.0	168.7	—	167.3
Two Bridges	Two Bridges Road	172.5	169.6	—	167.3
Caldwell	Horse Neck Bridge	174.8	169.7	—	167.9
Pine Brook	Routes 6 and 46	—	—	171.6	167.8
Pine Brook	Bloomfield Ave.	175.5	170.0	—	168.8
East Hanover	Swinefield	176.2	170.7	—	169.3
East Hanover	Route 10	176.5	171.6	—	169.5
East Hanover	Hanover-Cook Bridge	176.6	171.6	—	169.8
Florham Park	Columbia - So. Orange Ave.	178.0	172.0	—	169.9
Lower Chatham	Passaic Avenue	180.0	173.2	—	171.8
Chatham	Morris Turnpike (Dam)	—	178.3	—	176.2
Chatham	Chatham Road - Summit Ave.	—	185.9	—	184.9
POMPTON RIVER					
Lincoln Park	Two Bridges	172.5	169.6	168.6	167.1
Mountain View	Boonton Road	174.3	170.5	168.9	171.4
Wayne	D.L. & W.R.R.	177.5	172.0	172.5	173.9
Pequannock	Greenwood Lake Branch Erie R.R.	181.4	175.0	—	176.0
Pequannock	Newark and Pompton Turnpike	183.5	175.8	175.5	177.2
Pequannock	Newark Water Supply	183.5	176.0	—	177.2
Pequannock	Route 23	184.0	176.5	176.6	180.9
Pompton Plains	Jackson Avenue	186.8	179.0	—	181.9
PEQUANNOCK RIVER					
Pompton Plains	N.J. District W.S. footbridge	—	—	—	184.8
Pompton Plains	Elmwood Avenue	—	—	—	186.2
Riverdale	Riverdale Road	—	—	—	188.4
Pompton	Paterson Hamburg Turnpike	—	—	—	200.3
Pompton Lakes	N.Y. & Greenwood L.Div., Erie R.R.	—	—	—	210.5
Riverdale	Private Road	—	—	—	221.3
Riverdale	N.Y.S. & W.R.R.	—	—	—	234.3
RAMAPO RIVER					
Pompton	Colfax (Dawes Highway)	190.8	183.0	—	185.1
Pompton Lakes	Norton House (Pompton Turnpike)	192.0	184.1	—	189.3
Oakland	N.Y.S. & W.R.R.	224.0	214.0	—	215.0

**NOTE:** All elevations in feet above mean sea level at Sandy Hook, N. J.



GOVERNOR'S PASSAIC VALLEY FLOOD CONTROL COMMITTEE

PASSAIC RIVER FLOOD CONTROL  
AREA FLOODED IN OCTOBER 1903

SCALE OF MILES

TABLE C1  
ANTECEDENT RAINFALL PRIOR TO MAJOR FLOODS - PASSAIC RIVER BASIN

Date of Flood	Antecedent Month	Rainfall* Inches	Average Mo. Rainfall Inches	Percent of Av. Monthly Rainfall	Date of Flood	Antecedent Month	Rainfall* Inches	Average Mo. Rainfall Inches	Percent of Av. Monthly Rainfall
July 17, 1865 (22,500 cfs)	June	7.11	4.17	170	Mar. 2, 1902 (22,500 cfs)	Feb.	5.48	3.64	150
	May	9.36	4.12	227		Jan.	4.89	3.65	134
	Apr.	3.89	3.59	108		Dec.	6.85	3.91	175
	Mar.	7.40	4.15	178		Nov.	1.30	3.78	34
	Feb.	4.60	3.88	119		Oct.	6.06	4.24	143
	Jan.	4.89	3.73	131		Sept.	7.86	4.49	175
	Total	37.25	23.64	157		Total	32.44	23.71	137
Dec. 12, 1878 (16,590 cfs)	Nov.	4.57	3.43	133	Oct. 10, 1903 (34,000 cfs)	Sept.	3.29	4.49	73
	Oct.	2.85	3.79	75		Aug.	7.78	4.63	168
	Sept.	2.54	3.77	67		July	3.79	4.66	81
	Aug.	8.06	4.92	164		June	9.45	4.36	217
	July	4.33	4.71	92		May	0.24	3.92	6
	June	2.44	3.89	63		April	4.42	4.14	107
	Total	24.77	24.51	101		Total	28.97	26.20	110
Sept. 25, 1882 (18,260 cfs)	Aug.	2.37	4.75	50	Mar. 13, 1936 (19,400 cfs)	Feb.	4.31	3.64	118
	July	7.02	4.76	148		Jan.	4.84	3.65	133
	June	9.00	4.17	216		Dec.	1.46	3.91	37
	May	13.46	4.12	326		Nov.	5.86	3.78	155
	Apr.	3.39	3.59	94		Oct.	5.72	4.24	135
	Mar.	5.80	4.15	140		Sept.	5.16	4.49	115
	Total	41.04	25.54	160		Total	27.35	23.71	115
Feb. 8, 1896 (17,220 cfs)	Jan.	1.89	3.65	52	July 23, 1945 (19,500 cfs)	June	4.46	4.36	102
	Dec.	3.89	3.91	100		May	8.74	3.92	222
	Nov.	4.86	3.78	129		Apr.	4.22	4.14	102
	Oct.	4.08	4.24	96		Mar.	2.20	4.06	54
	Sept.	1.03	4.49	23		Feb.	3.95	3.64	108
	Aug.	2.38	4.63	51		Jan.	4.65	3.65	127
	Total	18.15	24.70	74		Total	28.22	23.77	119

\* Rainfall measured at: Charlotteburg Station for Period 1895 to 1945;  
Paterson Station for Period 1864 to 1895, except for Newark Station for 1878  
NOTE: Peak discharge measured at Dundee Dam, Paterson

## APPENDIX D

### SUMMARY—LOWER RIVER INVESTIGATIONS

(Reprinted from Russell S. Wise Report dated March 15, 1955)

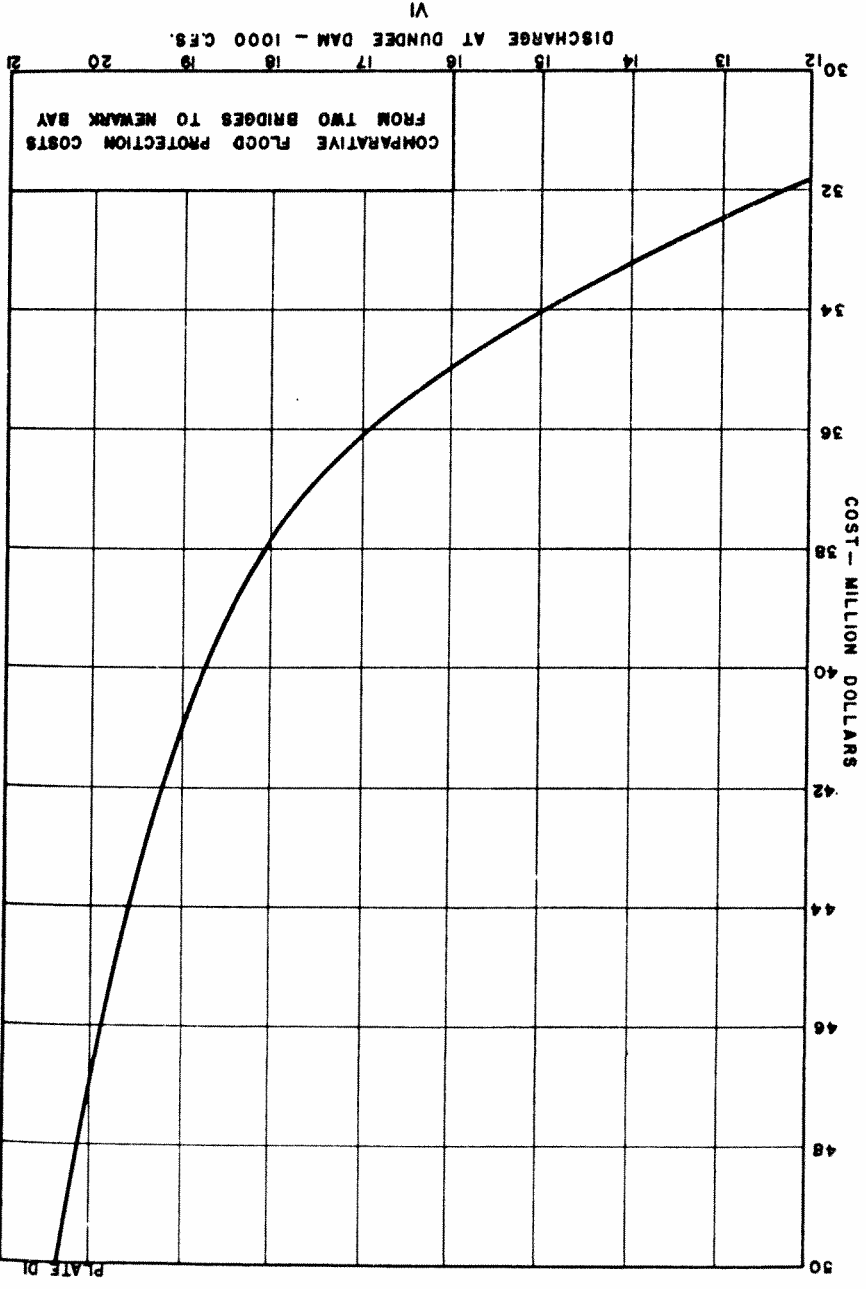
The results of this study can be briefly summarized by stating, first, the obvious fact that the existing river channel from Eighth Street bridge in Wallington to Two Bridges is inadequate for flood flows, and, second, that the cost of providing protection against floods greater than 16,000 cfs, measured at Dundee Dam, increases rapidly as the design flood is increased. The magnitude of the problem in the lower river may be realized by examining some of the items required in an improvement project designed to discharge a flood of 16,000 cfs at Dundee Dam. For example, 4 million cubic yards of earth and 250,000 cubic yards of rock must be removed from the channel to provide the necessary width and depth. In addition, 20 miles of concrete and steel sheeting walls of various heights are required to confine the flood flow. Two dams need to be completely rebuilt. Ten bridges, including three railroad bridges, must either be rebuilt or be modified. Furthermore, over 1½ million dollars worth of land and buildings must be acquired to provide sufficient width. The total cost of such a project is estimated to be approximately 35 million dollars. But the cost of a project for a design flood of 20,000 cfs at Dundee Dam is roughly estimated to be about 30 percent greater or approximately 46 million dollars.

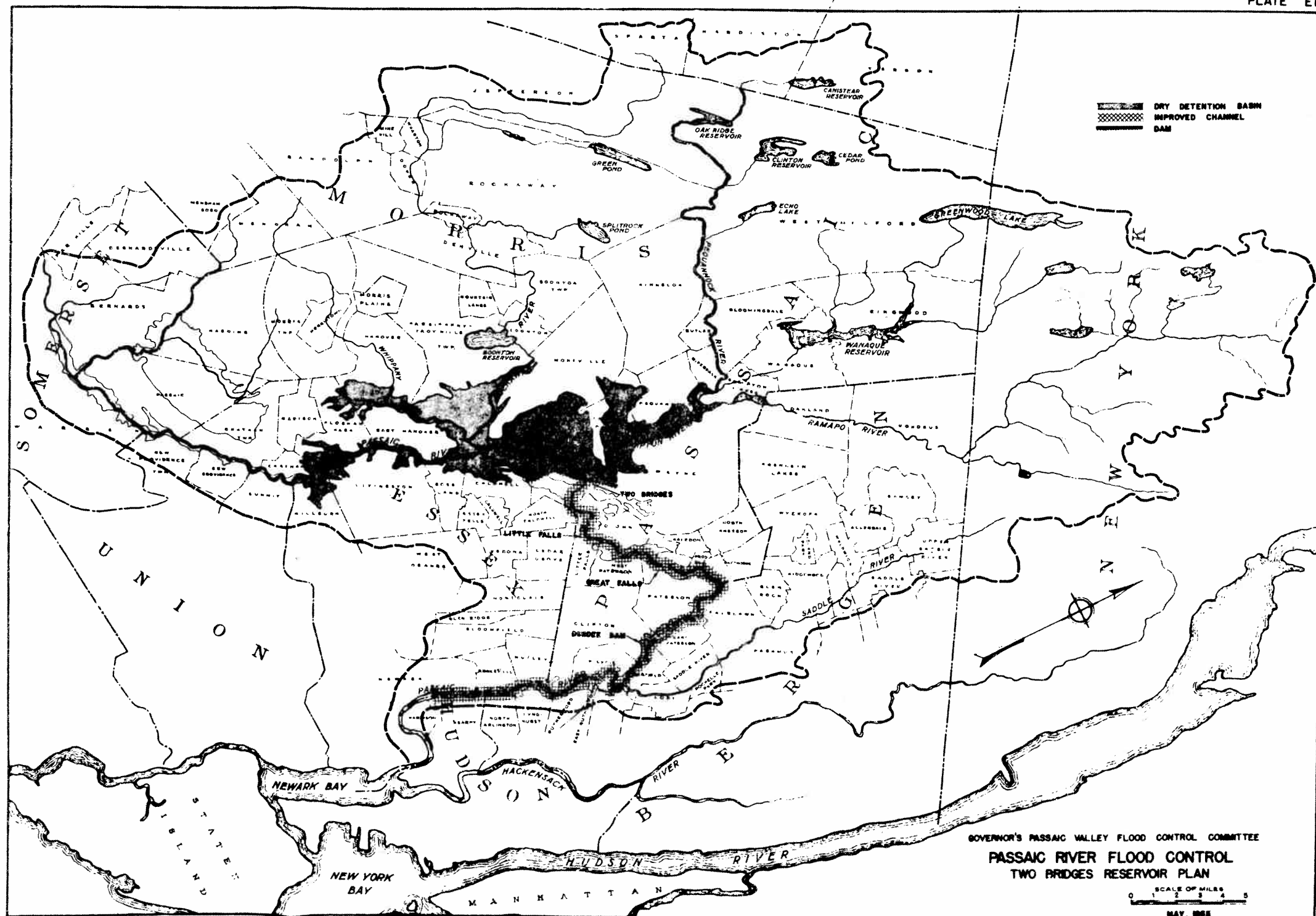
The greatest increase in cost will occur downstream of Dundee Dam where additional walls and interior drainage facilities will have to be provided if the design flood discharge is greater than 16,000 cfs. Land cost can be somewhat lessened by providing for a vertical side wall channel instead of a trapezoidal channel. Widening the river is not considered desirable mainly from a hydraulic engineering viewpoint and secondarily for economic reasons. Considerable deepening is recommended from the end of the navigation channel at Eighth Street bridge to Dundee Dam.

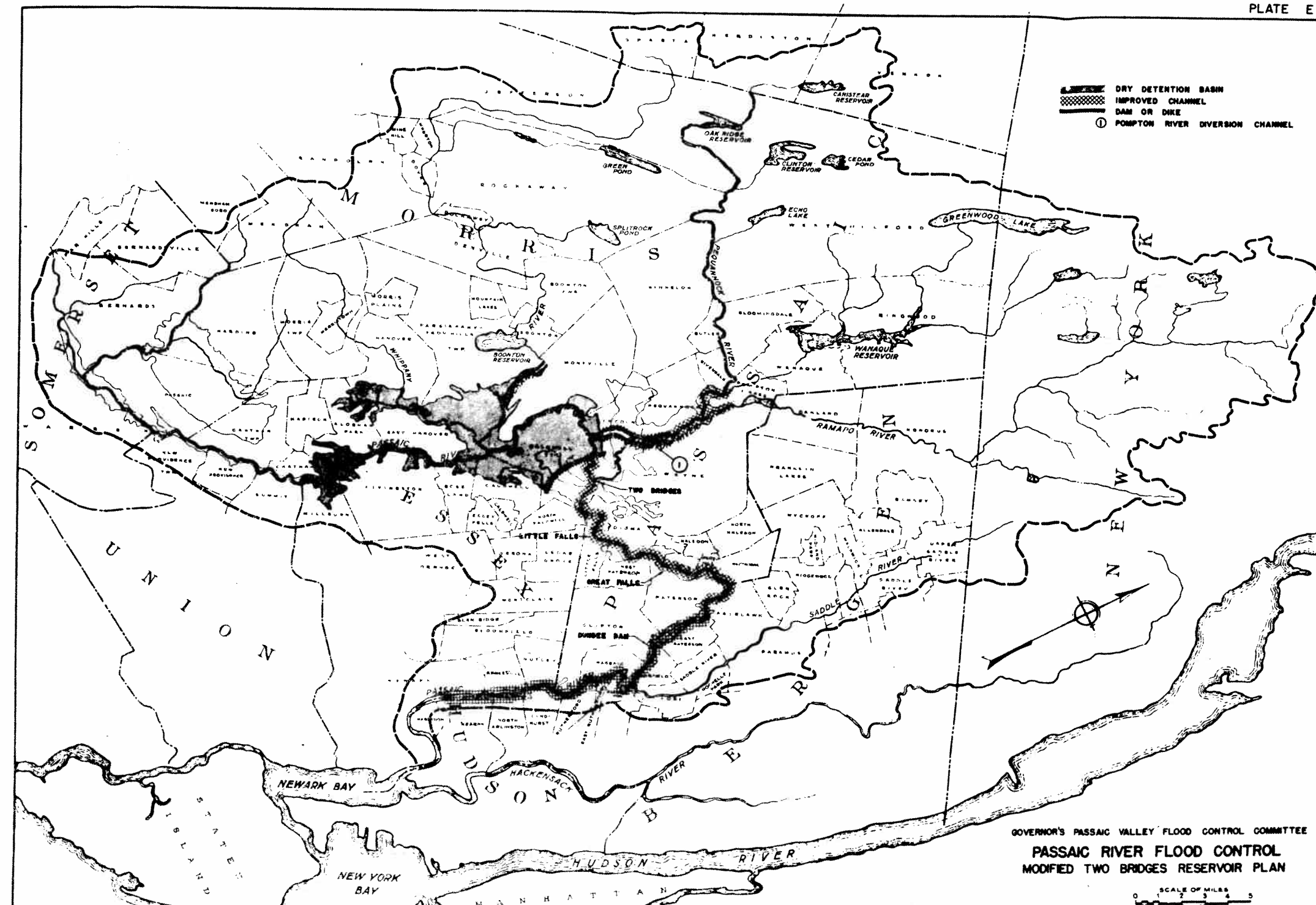
Through the Dundee Dam-Great Falls reach, a trapezoidal channel is proposed for the portion downstream of the Erie R.R. bridge and a rectangular channel upstream of Sixth Street bridge. The rectangular channel through the City of Paterson is considered necessary because of the presence of existing large buildings and high property values. The difference in the cost of channel improvement in this reach is 1.9 million dollars between 12,000 and 16,000 cfs, and 2.7 million dollars between 16,000 and 20,000 cfs. These differences in estimated costs for the three discharges are largely due to the increase in wall heights and the raising of bridges and approach roads. Widening, except through the center of Paterson, is not considered necessary from an engineering aspect nor is it considered economically feasible. Deepening in this reach is limited to a few high spots along the river except for a considerable amount of excavation at the head of Dundee Lake, downstream of Market Street bridge.

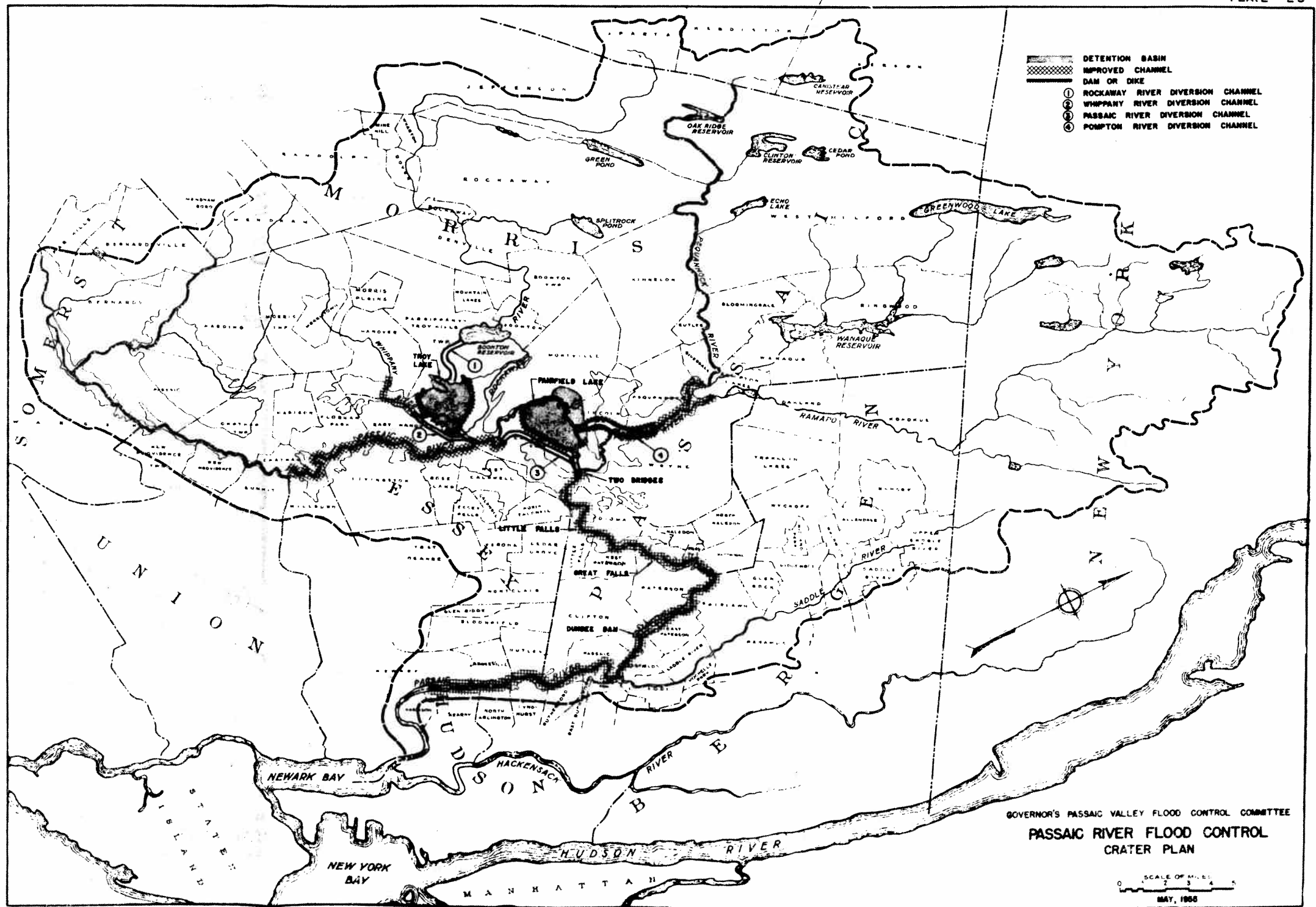
Practically the same design is proposed for the reach upstream of Beatties Dam as is proposed for the reach downstream of the dam. It is proposed that the existing dam be replaced by a series of movable gates and that the rock barrier, approximately 800 feet upstream of Beatties Dam, be lowered 9 feet. Considerable deepening, varying from 11 feet to 2 feet, is proposed along most of the river. If a greater design flood discharge is used, it is possible to widen or further deepen the channel to provide the same flow line for the increased discharge. However, the number of movable gates will have to be increased.

In order to lower the flow line in the reach of the river from Great Falls to Beatties Dam, it is proposed to replace the existing concrete dam on Great Falls with 4 movable gates. In addition, it is also proposed to lower a rock barrier, located approximately 3000 feet upstream from the falls, 5 feet. Little additional deepening is considered necessary unless the design flood discharge is substantially increased. Widening is limited to the narrow portions of the river. Additional widening is not required for a flood discharge of 12,000 cfs if the dam at the crest of Great Falls is replaced with movable gates.





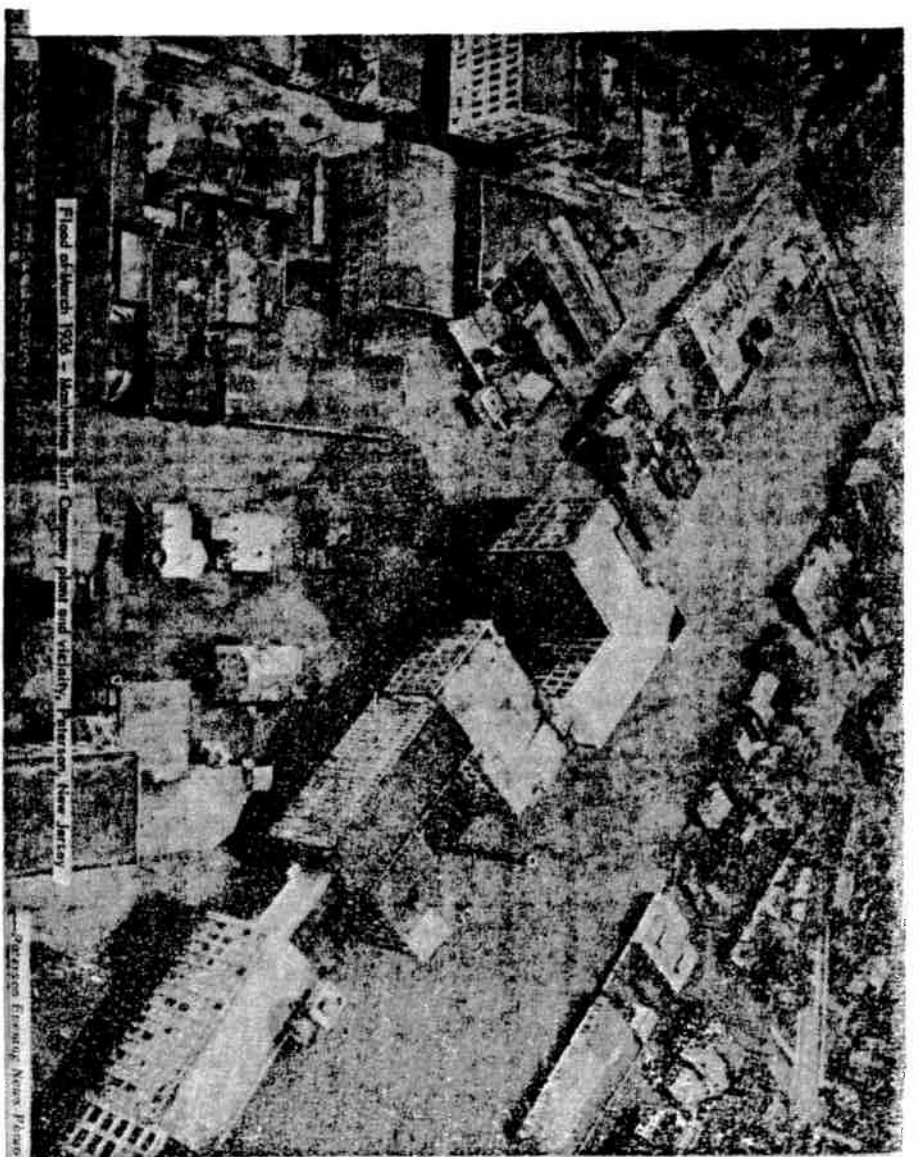






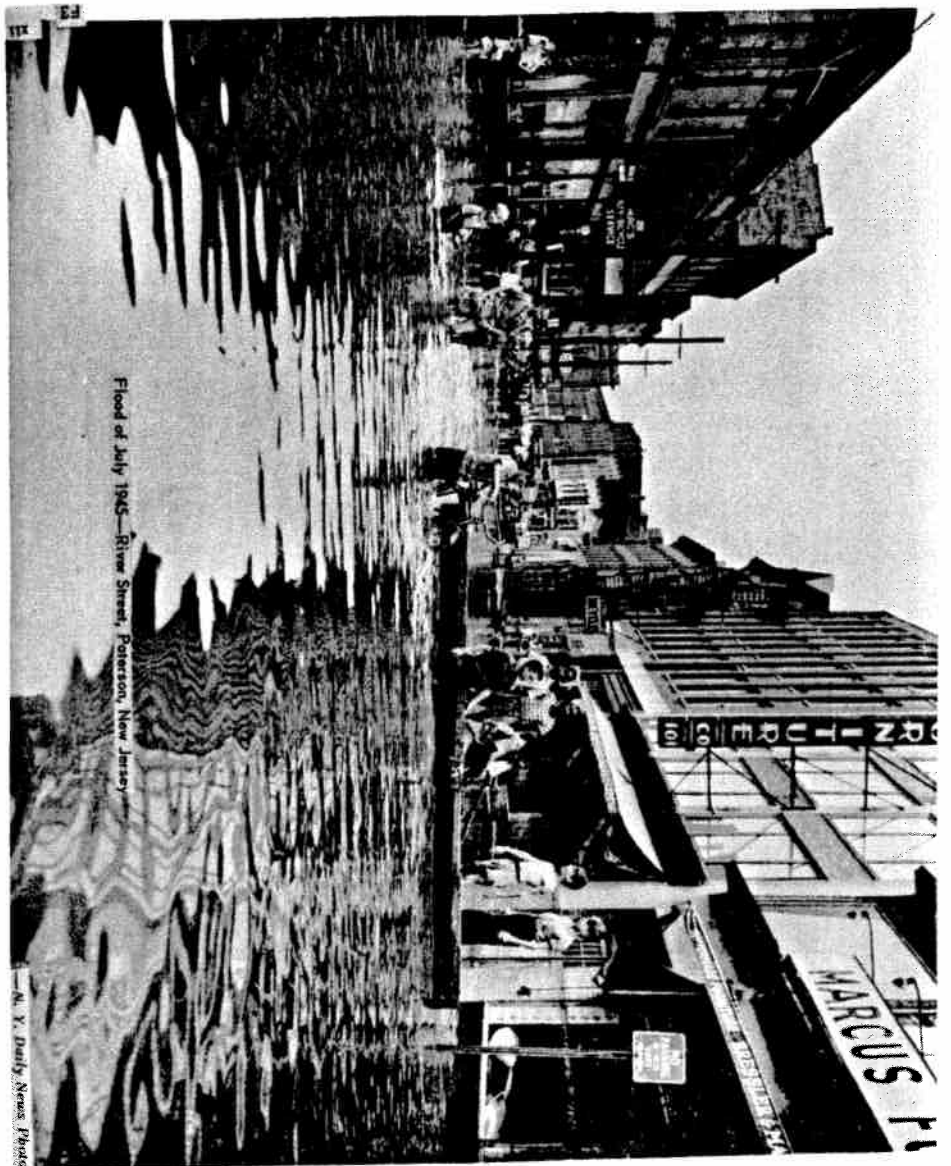
Flood of March 12, 1945

This house at Wayne, N. J., was a haven of refuge for forty persons who took refuge there and were rescued when flood waters rose. Police boat is rescuing last of those who climbed to top floor to escape flood waters. The outis in the foreground are almost entirely submerged.



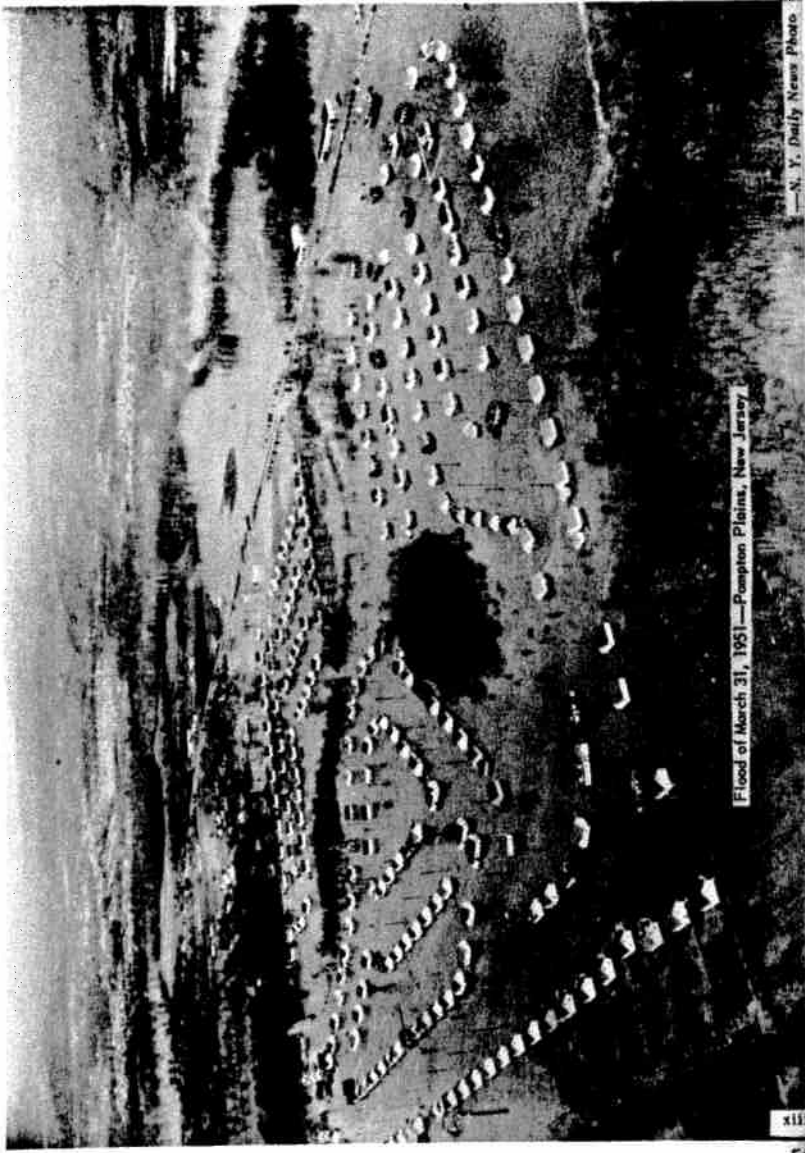
Flood of March 1926 - Manhattan Air Cooled Plant and vicinity, Paterson New Jersey

—Paterson Evening News-Press



Flood of July 1945—River Street, Paterson, New Jersey

—N. Y. Daily News Photo



Flood of March 31, 1951—Pompton Plains, New Jersey

—N. Y. Daily News Photo

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